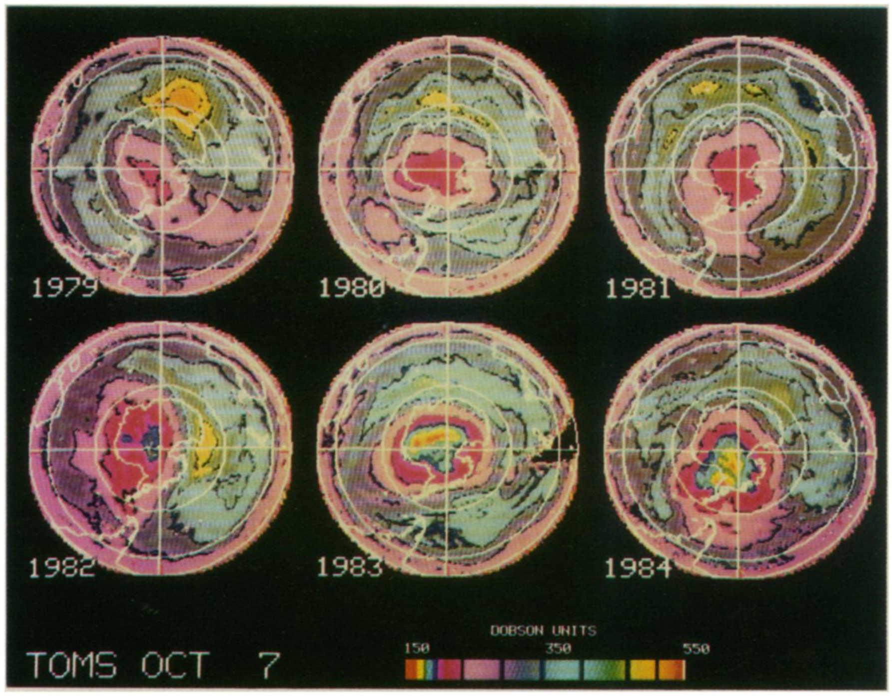
Ozone hole at southern pole



NASA

In these maps produced by the Total Ozone Mapping Spectrometer aboard the Nimbus-7 satellite, Antarctica is outlined in white and the rim of the map is the equator. The spectrum of colors corresponds to Dobson units, a measure of ozone content in an atmospheric column. In 1979, for example, there was an ozone high (yellow-orange) in the upper right quadrant, while the red region is the ozone hole. For the past several years this seasonal drop in ozone has become more severe.

Ozone, the atmospheric chemical that shields earth life from harmful ultraviolet radiation, has had a volatile political and scientific history. Battles have been waged over the extent to which chlorofluorocarbons (CFCs) and other chemicals injected into the atmosphere, primarily by human endeavors, attack the ozone layer (SN: 9/14/85, p. 165). Predictions of the resultant ozone depletion occurring globally in the next century have ranged from 3 to 18 percent as scientists work to unravel the mind-boggling complexity of atmospheric chemistry (SN: 4/12/82, p. 244).

But as researchers have pored over the data in search of very subtle annual changes in global ozone chemistry, they have failed to notice that the South Pole's ozone concentration during October has dropped much more drastically – by 40 percent since the mid-1970s.

Scientists now know that an "ozone hole" looms over the entire continent of Antarctica every October and has been getting more severe each year.

This effect was "totally unexpected," says atmospheric scientist Richard Stolarski of the NASA Goddard Space Flight Center in Greenbelt, Md. The big question now, he stresses, is whether the effect is a forewarning of a significant change in global ozone, or simply an isolated scientific curiosity.

Because of its potential importance, the ozone hole has fanned considerable excitement. The finding was added at the last minute to a recent international report on the upper atmosphere, coordinated by NASA. And scientists are now planning atmospheric measurements to test an evolving body of ideas proposed to explain the phenomenon.

The first indication that October ozone levels were dropping came from Joe C. Farman and his colleagues at the British Antarctic Survey, which has measured ozone levels from Halley Bay, Antarctica, since 1957. Last May, Farman's group published a paper in NATURE showing how total ozone values at Halley Bay were much lower in October than in March – an effect that did not appear in the 1957-through-1973 data.

Intrigued by Farman's finding, Stolarski and others rummaged through the reams of data taken by an instrument called the Total Ozone Mapping Spectrometer (TOMS) on the polar-orbiting Nimbus-7 satellite launched by NASA in 1978. Sure enough, the seasonal drop in ozone was clearly apparent. The hole begins to form in the Antarctic spring, about a month after the sun starts to graze the horizon. In early November the hole starts to disappear, in part because the sun has been high enough in the sky by that time for ozone-producing ultraviolet rays to penetrate the air.

Scientists say the hole has no counterpart at the North Pole. What, then, makes the atmosphere over Antarctica so special? Unlike the Northern Hemisphere, the South has no continents and mountain ranges extending toward the pole from other latitudes, an arrangement that would bring air currents to mix with the atmosphere at the pole. As a result, there are no ozone-laden currents to replenish the ozone supply over the South Pole as it is depleted. Moreover, Antarctica is colder than the Arctic, because there are no air currents to bring in heat and because the ice-covered continent doesn't absorb the sun's rays very well. These conditions also favor the formation of nocturnal stratospheric clouds.

But the special conditions above Antarctica don't explain how the hole forms or, more important, why the concentration of ozone during October has been rapidly decreasing from year to year. A number of researchers have suspected chlorine, an element that catalytically destroys ozone, because it has been on the rise since the use of CFCs began. Susan Solomon at the National Oceanic and Atmospheric Administration in Boulder, Colo., and her co-workers have proposed that during the polar night, hydrochloric acid (HCl) and chlorine nitrate ($ClONO_3$) – two "reservoir" species that normally tie up chlorine so it can't destroy ozone – react to form molecules of chlorine gas. When the sun comes out, its visible light breaks down the chlorine gas into individual chlorine atoms, which destroy the ozone – even as the ultraviolet light is producing ozone. The reaction between HCl and $ClONO_3$ has been observed on the surfaces of laboratory equipment; perhaps the nocturnal clouds produced over Antarctica also provide the surfaces necessary for such a reaction.

Still, says Stolarski, "There is no proof at this time that it [the increasing severity of the ozone hole] is indeed a chlorine effect." Other possibilities include dynamics – how the upwelling movement of air might create ozone lows – and the volcanic eruptions of aerosols.

The chemistry of the ozone layer worldwide is also plagued by uncertainties. But as the recent NASA report concludes, researchers now have compelling observational evidence that trace gases other than CFCs – such as methane, nitrous oxide and carbon monoxide – are increasing on a global scale (SN: 5/18/85, p. 308). And scientists now realize that the trace gases affecting ozone chemistry are the same as those that contribute to or alter the greenhouse warming of the planet; the two problems are intimately coupled. The report, to which 150 scientists from 11 nations contributed, concludes: "Given what we know about the ozone and trace-gas-climate problems, we should recognize that we are conducting one giant experiment on a global scale by increasing the concentrations of trace gases in the atmosphere without knowing the environmental consequences." *– S. Weisburd*